CHIVO Radar Data - Version 1.0

1. Data Set Description

This dataset contains radar moments data in CfRadial format, collected by the CHIVO radar during the Preparatory Rockies Experiment for the Campaign In the Pacific (PRE-CIP). During PRE-CIP, CHIVO was located NE of Fort Collins, CO (40.6117 N, 104.996 W, 1.547 km altitude) and collected data from May 2 to August 25, 2021. This release contains both Level 2 and Level 3 products.

2. Instrument description

The Colorado State University C-band Hydrological Instrument for Volumetric Observation (CSU-CHIVO) radar is a ground-based, polarimetric, commercial grade C-band weather radar. The radar operates in simultaneous transmit and receive mode.

CHIVO Radar Characteristics	
Transmitter	5.625 GHz
Pulse Width	1.0 μs
PRF	1500 Hz for RHIs, 1200 Hz for PPIs
Peak Power	250 kW
Noise Power	-110 μm
Radar Noise Figure	< 2 dB
Dynamic Range	> 99 dB
Bandwidth	1 MHz
Minimum detectable signal	-110 dBm
Polarization Switching	Simultaneous transmit and receive
Gain	45 dBi
Diameter	4.5 m
Beamwidth	0.95º
Peak sidelobe	< -29 dB (typically < -30 dB)
Scan rate	5º/s for RHIs, 12-17º/s for PPIs
Number of range gates	647 for RHIs, 799 for PPIs
Gate Spacing	0.15 km

3. Data collection and processing

CHIVO scanned on a 12-minute cycle that coordinated with CHILL and ran nearly continuously over the project. The 12-minute cycle consisted of a curtain RHI scan beginning at 281º and ending at 101º, a surveillance scan that consisted of elevation angles from 0.5º to 15º, a dedicated RHI scan pattern that scanned over the cardinal and ordinal directions, CSU Atmospheric Science/Christman Field, KFTG, Marshall Field (where S-Pol operated), and the Cameron Peak Burn Scar, and a user-selected scan that consisted either of RHI scans centered on nearby precipitation or a shallower surveillance scan.

Raw radar files were converted to CfRadial by RadxConvert.

Two QC procedures were performed to 1) remove the lowest quality signal and correct any measurement errors (Level 2) and 2) remove low-quality and non-weather echoes from the data and add value-added products (Level 3).

3.1 Level 2: high-quality radar measurements retained

To remove the lowest-quality signal, any gates where SQI < 0.2 and SNR < 0.0 dB were removed. This QC was applied to all variables using Python.

We identified an average ZDR bias of -0.4 dB over the full campaign after examination of high-elevation RHI1 data and SUR scans above the melting level. This bias is corrected and saved to the ZDR data.

Level 2 data contain bias-corrected and high-quality radar signals, which include both meteorological and non-meteorological echoes. These data are for experienced radar users who want access to the full radar measurements. For most meteorological applications, users should consider using the Level 3 data.

3.2 Level 3: high-quality meteorological data, including value-added products

Low-quality and non-meteorological echoes were removed from the dataset based on polarimetric values, the CSU RadarTools despeckling algorithm, and non-weather categories from the NCAR PID algorithm in RadxRate. Polarimetric variables used for thresholding included RHOHV, SNR, smoothed SQI (using a 2D Gaussian smoother), and the standard deviation of PHIDP.

KDP was calculated using RadxRate, with a FIR filter length of 10 gates and using the Hubbert and Bringi (1995) method to handle phase shift on backscatter. KDP is only considered valid in regions where the standard deviation of PHIDP is less than 20 and RHOHV is above 0.9.

For consistency with SEAPOL data from PRECIP 2022, both the NCAR PID and the CSU RadarTools HID were used to identify hydrometeor types. Soundings for the PID and HID were obtained from the 6-hourly GFS model analysis. The summer HID algorithm (Dolan et al. 2013; Rutledge et al. 2019) uses RHOHV, attenuation-corrected DBZ and ZDR, and KDP.

Attenuation-corrected DBZ and ZDR are calculated using the default C-band coefficients available in RadxRate. These Level 3 products are labeled DBZ and ZDR in the final dataset; the variables prior to attenuation correction are referred to as DBZ_ATTEN_UNCORRECTED and ZDR_ATTEN_UNCORRECTED.

Rain rates are estimated using RATE_HYBRID and RATE_HIDRO (Cifelli et al. 2011) methods available in RadxRate. Coefficients for R(Z), R(Z, ZDR), and R(KDP) were taken from Ryzhkov et al. (2022).

These Level 3 products have removed the majority of non-meteorological echoes and are recommended for general use. Users who want more control over the quality control processing are recommended to use the Level 2 data.

Processing scripts and parameter files are available on GitHub.

4. Data Format

The moments data described here are available at <link> in CfRadial format. For more information on CfRadial see https://www.eol.ucar.edu/system/files/CfRadialDoc-v2.0-20180430.pdf.

The primary data products for scientific use are listed in the table below.

Variable	Dimensions Unit	Long Name
time	time s	Seconds since volume start
range	range m	Range from instrument to center of gate
azimuth	time deg	Ray azimuth angle
elevation	time deg	Ray elevation angle
DBZ_L2	n_points dBZ	Level 2 Reflectivity
VEL_L2	n_points m/s	Level 2 Doppler velocity
WIDTH_L2	n_points m/s	Level 2 Spectrum width
ZDR_L2	n_points dB	Level 2 Bias-corrected differential reflectivity

PHIDP_L2	n_points deg	Level 2 Differential phase
DBZ	n_points dBZ	Level 3 Attenuation-corrected reflectivity
ZDR	n_points dB	Level 3 Attenuation-corrected and bias-corrected differential reflectivity
DBZ_ATTEN_UNCORRECTED	n_points dBZ	Level 3 Reflectivity
ZDR_ATTEN_UNCORRECTED	n_points dB	Level 3 Bias-corrected differential reflectivity
VEL	n_points m/s	Level 3 Doppler velocity
WIDTH	n_points m/s	Level 3 Spectrum width
PHIDP	n_points deg	Level 3 Differential phase
KDP	n_points deg/km	Level 3 Specific differential phase
RHOHV	n_points none	Level 3 Cross correlation ratio
PID	n_points	Hydrometeor particle ID from RadxRate
HID_CSU	n_points	Hydrometeor ID from CSU RadarTools
RATE_HYBRID	n_points mm/h	Hybrid precipitation rate from RadxRate
RATE_HIDRO	n_points mm/h	Precipitation rate from Cifelli et al. (2011) in RadxRate

5. Data Remarks

5.1 Known problems

The ZDR bias was considered as a system bias over the entire field project. If examining case studies or an event where rain was occurring (or had occurred recently), an additional ZDR bias correction may be necessary.

Attenuation correction at C-band may not be strong enough in heavy rainfall. Severe attenuation and differential attenuation are also possible in places behind intense precipitation. We recommend censoring or being cautious with the PID and precipitation rates where ZDR < -0.5.

Precipitation rates are calculated when hail is present, so we recommend caution using the rain rates when the PID states hail is present and KDP is low, because the precipitation rates are unreasonably high.

6. References

6.1 Data Citation

Colorado State University Radar Team: Michael Bell, V. Chandrasekar, Jennifer DeHart, Brenda Dolan, Jim George, Francesc Junyent, EunYeol Kim. 2023. PRE-CIP: CHIVO radar moments data. Version 1.0. Colorado State University. https://doi.org/. Accessed <insert data download date>.

6.2 References

Cifelli, R., V. Chandrasekar, S. Lim, P. C. Kennedy, Y. Wang, S. A. Rutledge, 2011: A New Dual-Polarization Radar Rainfall Algorithm: Application in Colorado Precipitation Events. *J. Atmos. Technol*, Vol 28, No 3, March, 352-364.

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Lang, T., Dolan, B., Guy, N., Gerlach, C., and Hardin, J. (2019). CSU-Radarmet/CSU_RadarTools: CSU_RadarTools v1.3 (v1.3). Zenodo. https://doi.org/10.5281/zenodo.2562063

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